

Technique and Application of Transcervical Extended Mediastinal Lymphadenectomy in Thoracic Surgery

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It is our institution's policy to propose primary radical surgery to patients with stage I and II non-small-cell lung cancer (NSCLC). However, patients with stage III N2 disease that is discovered preoperatively should be treated with neo-adjuvant chemotherapy or chemo-radiotherapy and subsequently operated on. We believe that lymphadenectomy improves the results of surgery, but we lack definitive evidence for this conclusion. To optimally improve preoperative staging of the mediastinal lymph nodes, our team introduced transcervical extended mediastinal lymphadenectomy (TEMLA) in

2004.¹ We have performed this procedure on more than 600 NSCLC patients since we began using this technique. Some other applications of this technique were tried for the treatment of myasthenia gravis, mediastinal tumors, esophageal cancer, for closure of the bronchial stump fistula after pneumonectomy, and for right upper lobe pulmonary resection. TEMLA was performed on patients with proven NSCLC who were candidates for pulmonary resection regardless of the state of the mediastinal nodes on computed tomography (CT) or positron emission tomography/CT, and after negative results from endobronchial ultrasound/transbronchial needle aspiration (EBUS/TBNA) and/or endoesophageal ultrasound (EUS). The aim of TEMLA is to accurately stage and improve late results of treatment of NSCLC. All mediastinal nodal stations (according to the Mountain-Dresler map), except for the pulmonary ligament nodes (station 9), were removed during procedure (Fig. 1).²

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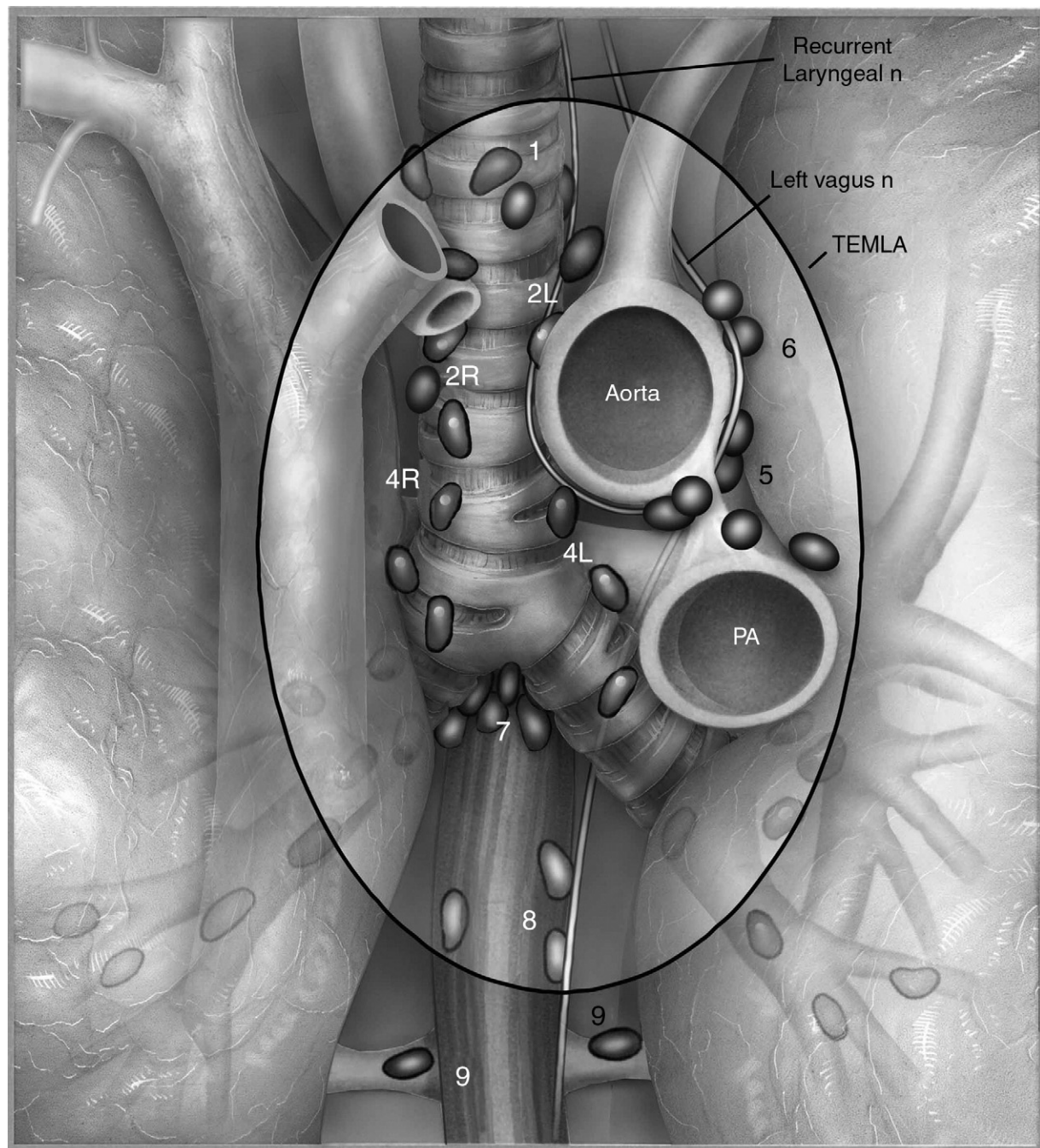


Figure 1 Extent of removal of the mediastinal nodes during TEMLA. n. = nerve; PA = pulmonary artery; TEMLA = transcervical extended mediastinal lymphadenectomy.

Surgical Technique of TEMPLA

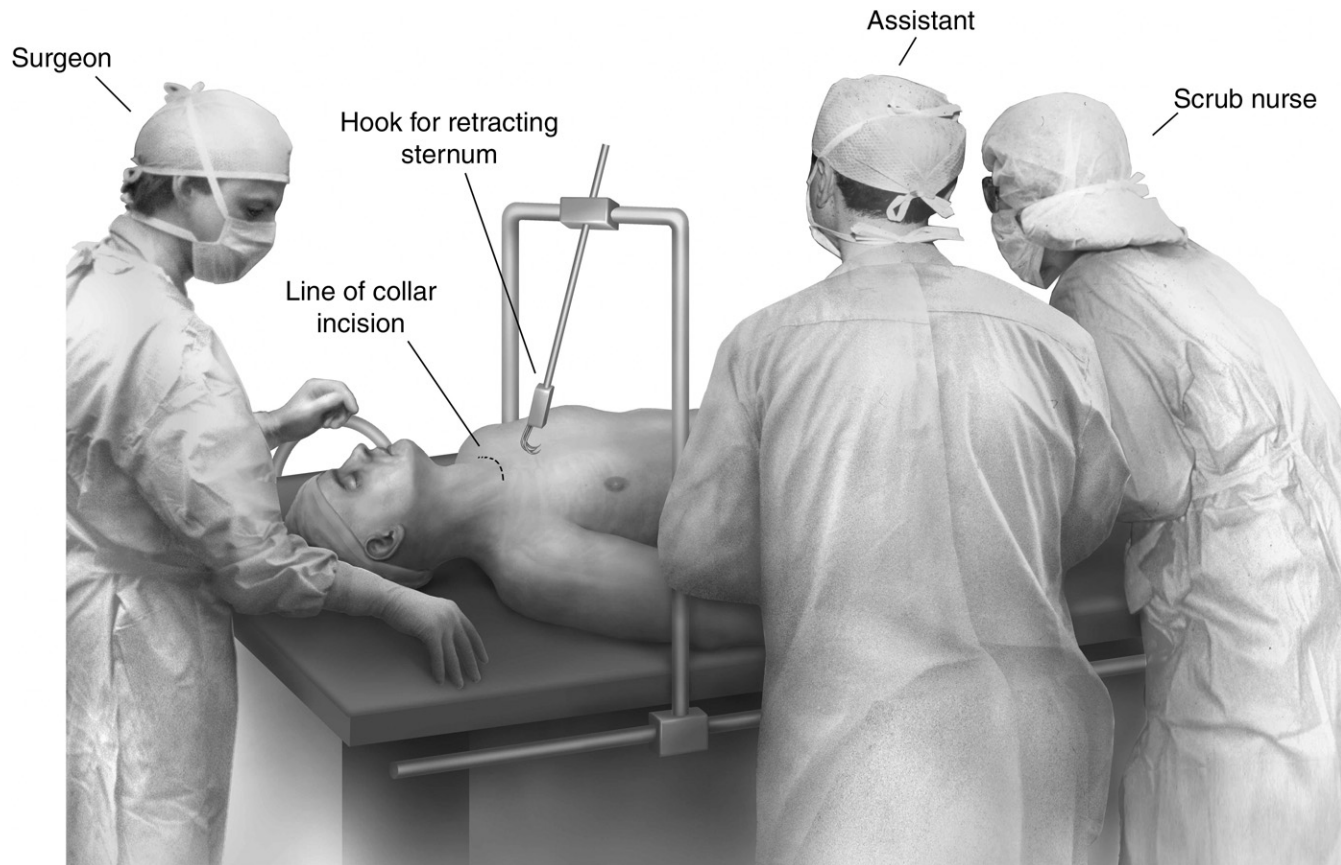


Figure 2 The view of the position of the members of the operating team.

General Principles

The position of the operating team is shown in Fig. 2. Generally, TEMPLA can be performed with two surgeons and one scrub nurse. The surgeon stands behind the patient's head and the assistant and scrub nurse stand to the patient's right side. In some exceptionally difficult cases or for surgeons who are only beginning to perform TEMPLA, having the second assistant standing on the left side of the patient may be helpful. We prefer to perform the operation with the use of electrosurgical coagulation or harmonic scalpel. However, it is also possible to achieve hemostasis with the use of vascular clips. Generally, TEMPLA is an open procedure that is performed under direct eye control with the use of normal surgical instruments developed for open surgical procedures.

Dissection of the Laryngeal Recurrent Nerves

The operation is performed through a collar incision in the neck just above the sternal notch. The length of incision is 5 to 8 cm. The platysma muscle is divided and the anterior jugular veins are exposed, suture-ligated, and divided. Bilateral visualization and protection of the laryngeal recurrent nerves are priorities. The technique used for visualization of

the laryngeal recurrent nerves is described elsewhere in the article.³ In short, to reach the nerve below the level of the thyroid gland, one must divide the deep cervical fascial layers covering the carotid arteries until the clean wall of the artery is reached. Traction is then applied on the carotid artery in the lateral direction and in the opposite direction on the trachea. This maneuver stretches the tissue between these structures containing the laryngeal recurrent nerves. With use of a blunt dissection with a peanut sponge, the laryngeal recurrent nerves can be safely visualized almost instantly. The key is not to dissect the nerve circumferentially and to leave the deepest layer of the fascial tissue covering the nerve. These maneuvers protect the nerve from injury. The right recurrent nerve runs from the division of the innominate artery to the larynx (Fig. 3). The left laryngeal recurrent nerve lies in the groove between the trachea and the esophagus (Fig. 4). The position of both nerves is almost always constant that we have never seen any anatomical variability of their position in more than 1200 operations with the laryngeal recurrent nerve dissection (including TEMPLA, transcervical-subxiphoid-VATS maximal thymectomies, the resection of the various mediastinal lesions, and the esophageal resections).

After visualizing both laryngeal recurrent nerves, the sternal manubrium is elevated with a sharp three-teeth hook connected to the Rochard frame (Aesculap-Chifa Co., Nowy Tomysl, Poland) to widen the access to the mediastinum.

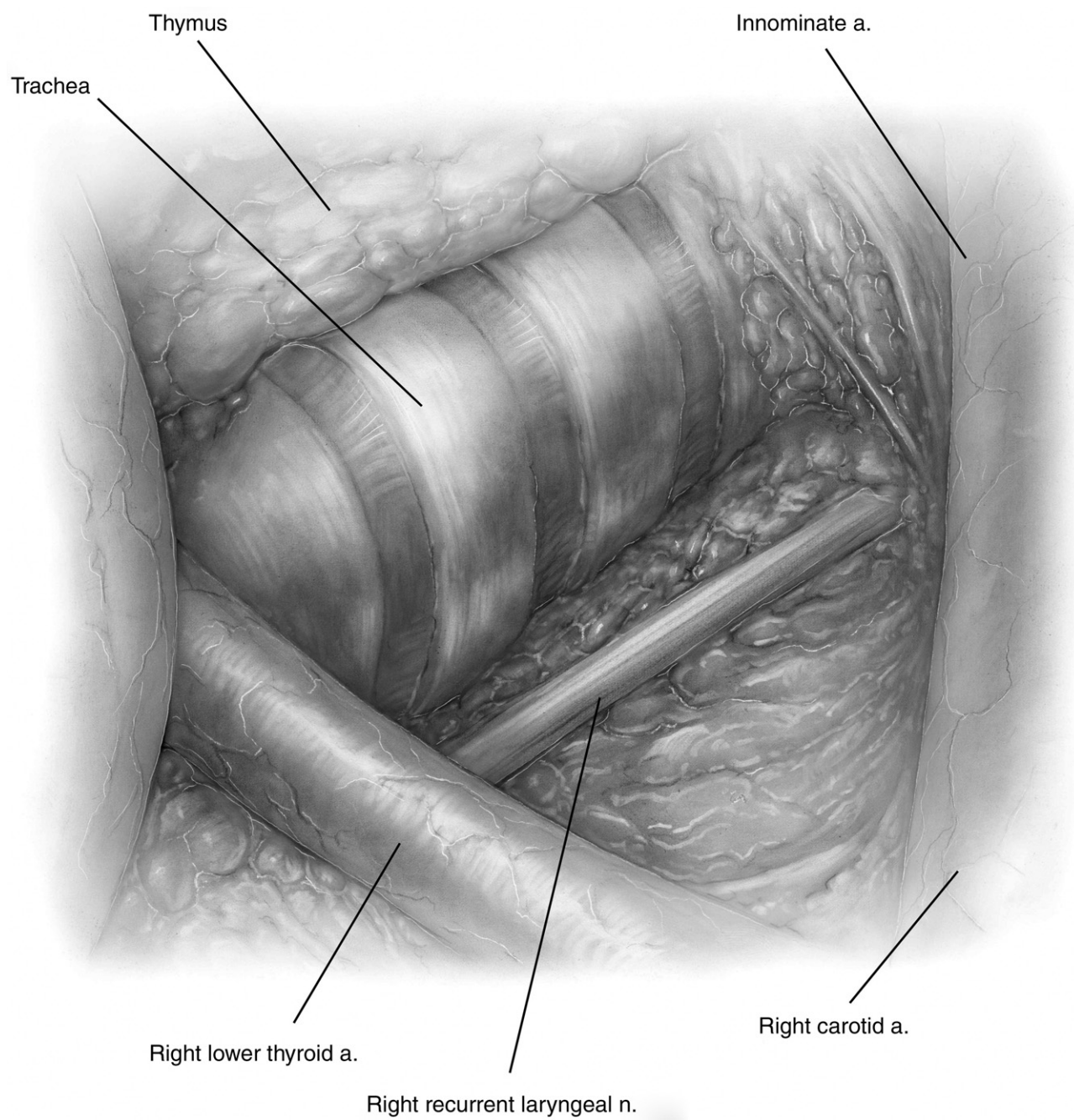


Figure 3 Dissection of the right laryngeal recurrent nerve. a. = artery; n. = nerve.

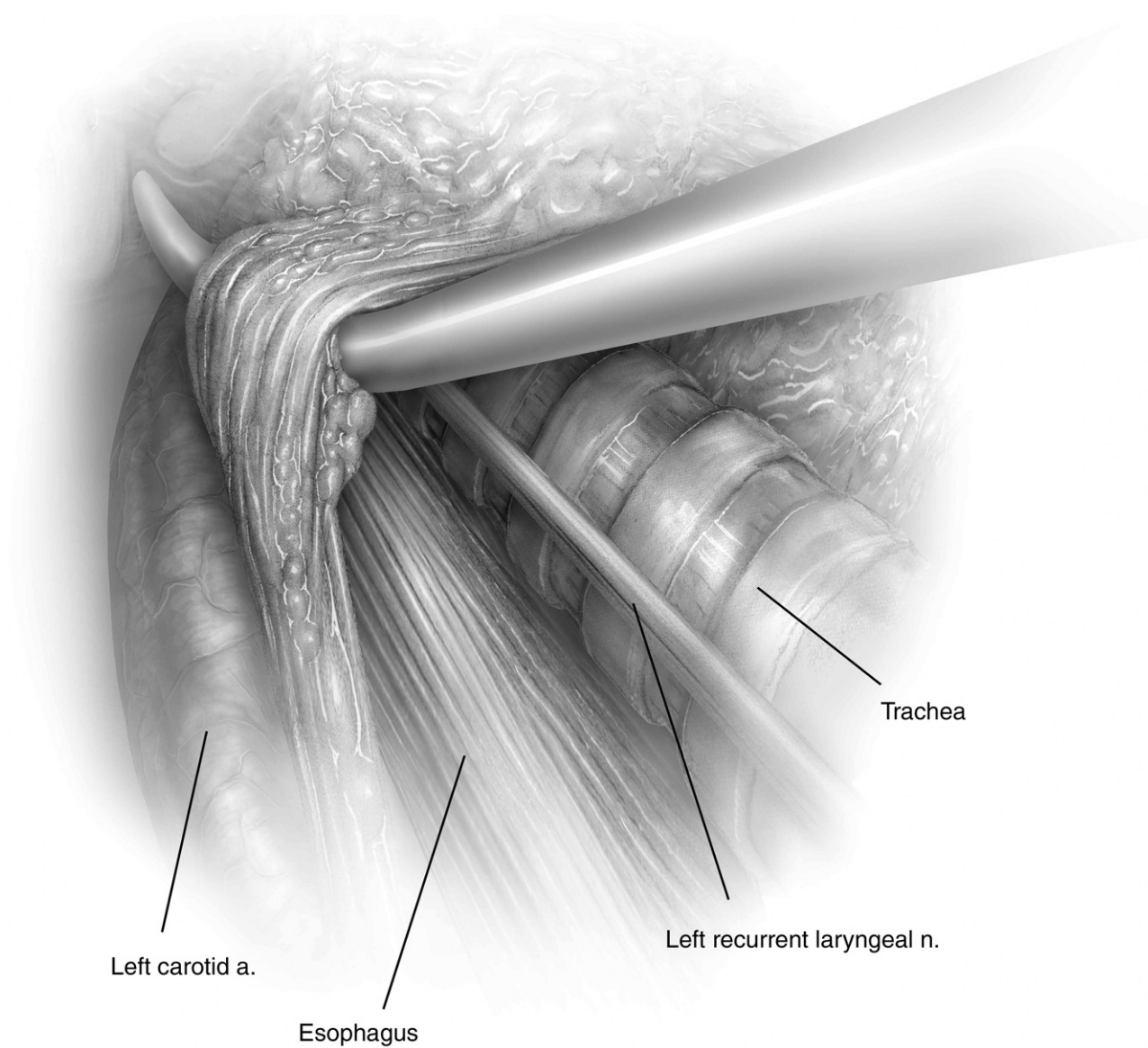


Figure 4 Dissection of the left laryngeal recurrent nerve. To expose the nerve, the vascularized fascial layers covering the nerve must be divided. a. = artery; n. = nerve.

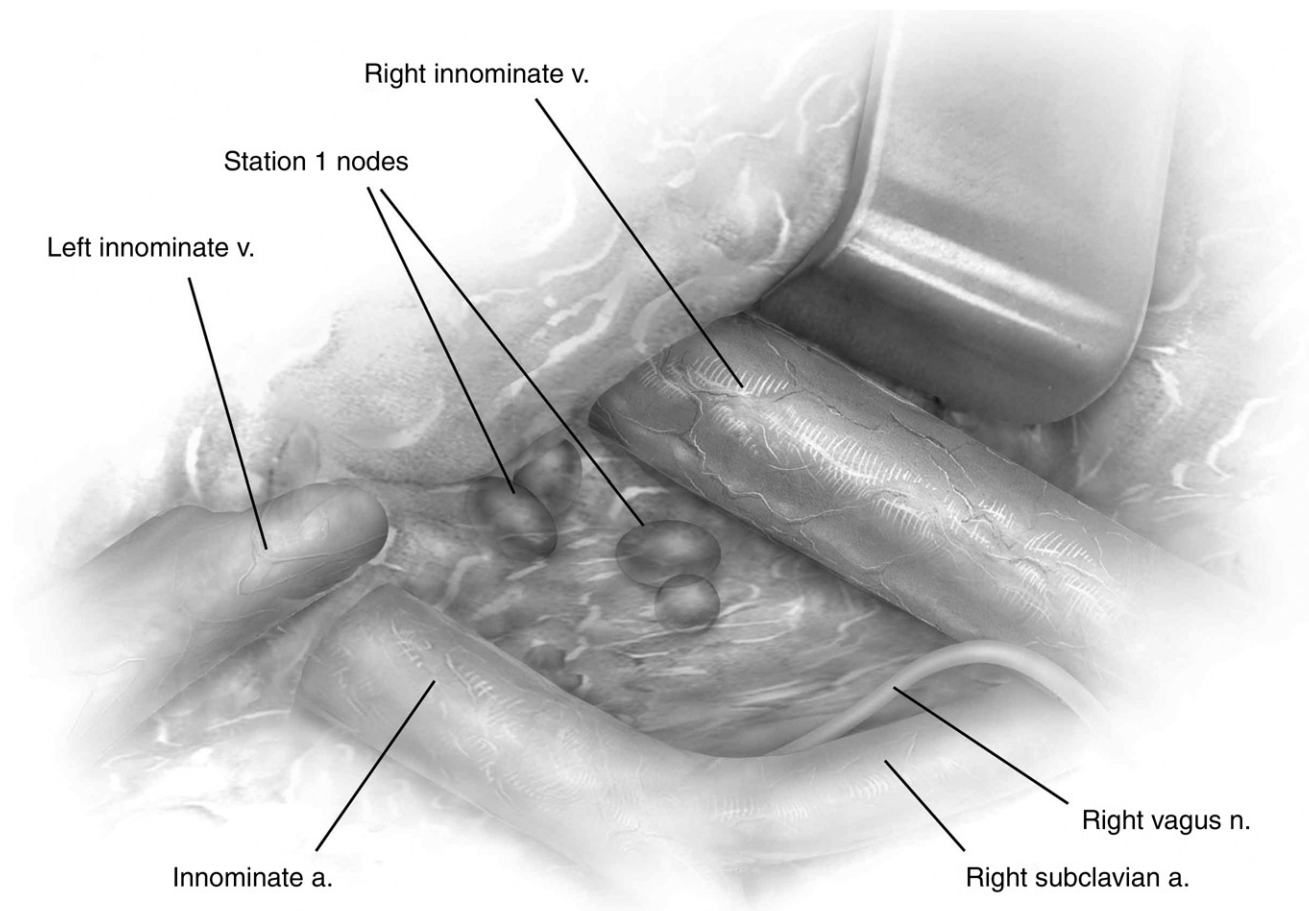


Figure 5 Dissection of the highest mediastinal nodes (station 1). a. = artery; n. = nerve; v. = vein.

The Highest Mediastinal Nodes (Station 1)

The highest mediastinal nodes (station 1) are dissected first. These nodes are located above the upper margin of the left innominate vein and belong to the anterior lymphatic flow from the chest. The fatty tissue containing these nodes is dissected from the right carotid artery and the right innominate veins (laterally, on the right side), from the left carotid artery (laterally, on the left side), and then is dissected from the trachea (posteriorly) and from the left innominate vein (inferiorly). The piece of tissue containing the station 1 nodes is resected en bloc along with the upper poles of the thymus gland.

The Right Paratracheal Nodes (Stations 2R and 4R)

Entering the right paratracheal space containing stations 2R and 4R is done by dissecting along the right vagus nerve, which is located between the right carotid artery and the right jugular vein (Fig. 5). The dissection proceeds along the nerve, below the division of the innominate artery. The origin of the right laryngeal recurrent nerve is clearly visible and protected from injury. Dissection proceeds toward the tracheal bifurcation. All the fatty tissue containing the 2R and 4R nodes lying between the right innominate vein and the right mediastinal pleura (laterally), the ascending aorta and trachea (medially), the back wall of the superior vena cava (anteriorly), the esophagus and the thoracic spine (posteriorly), the right main bronchus, the azygos vein, and the right pulmonary artery (inferiorly) is removed. Any vessels in this

area can be handled with vascular clips, electrosurgical coagulation, harmonic knife, or cautery (Fig. 6).

The Left Paratracheal Nodes (Stations 2L and 4L)

The next step is to dissect the left paratracheal space. By retracting the trachea to the right side and the left common carotid artery to the left and upwards, this enables excellent visualization of the entire left paratracheal space to the proximal one-third of the left mainstem bronchus. The dissection proceeds along the left laryngeal recurrent nerve below the level of the tracheal bifurcation. The nerve is dissected from the left wall of the trachea and the left main bronchus with a peanut sponge, while lateral connections of the nerve are preserved to maintain the blood supply. Division of the fascial layer covering the nerve is usually necessary to visualize the nerve. In most patients, the left upper paratracheal nodes (station 2L) are located medially and in front of the nerve, while the lower paratracheal nodes (station 4L) almost always lie behind it (Fig. 7). Carefully preserving the left laryngeal recurrent nerve, the lymph nodes 2L and 4L are dissected. Our current practice is to dissect the most distal 4L nodes with the aid of a mediastinoscope. We have found that it is also helpful in removal of the most distal lower paratracheal nodes (station 4L) in some patients, reaching the division of the left main stem bronchus. In these patients, removal of the lower paratracheal nodes (station 4L) is postponed until the subcarinal and the periesophageal nodes are removed.

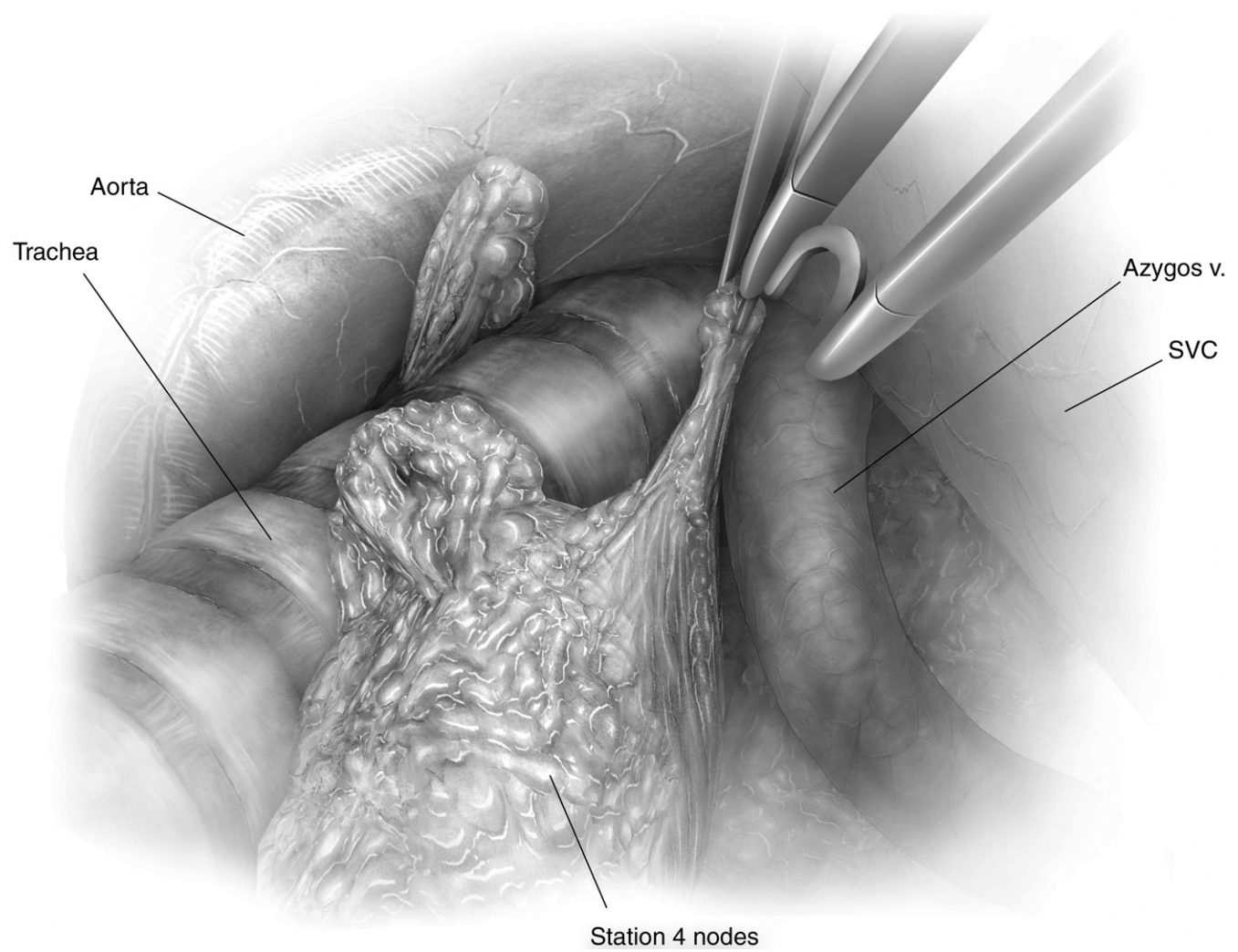


Figure 6 Dissection of the lower paratracheal nodes (station 4R) from the ascending aorta, the azygos vein, the trachea, and the right main bronchus. SVC = superior vena cava; v. = vein.

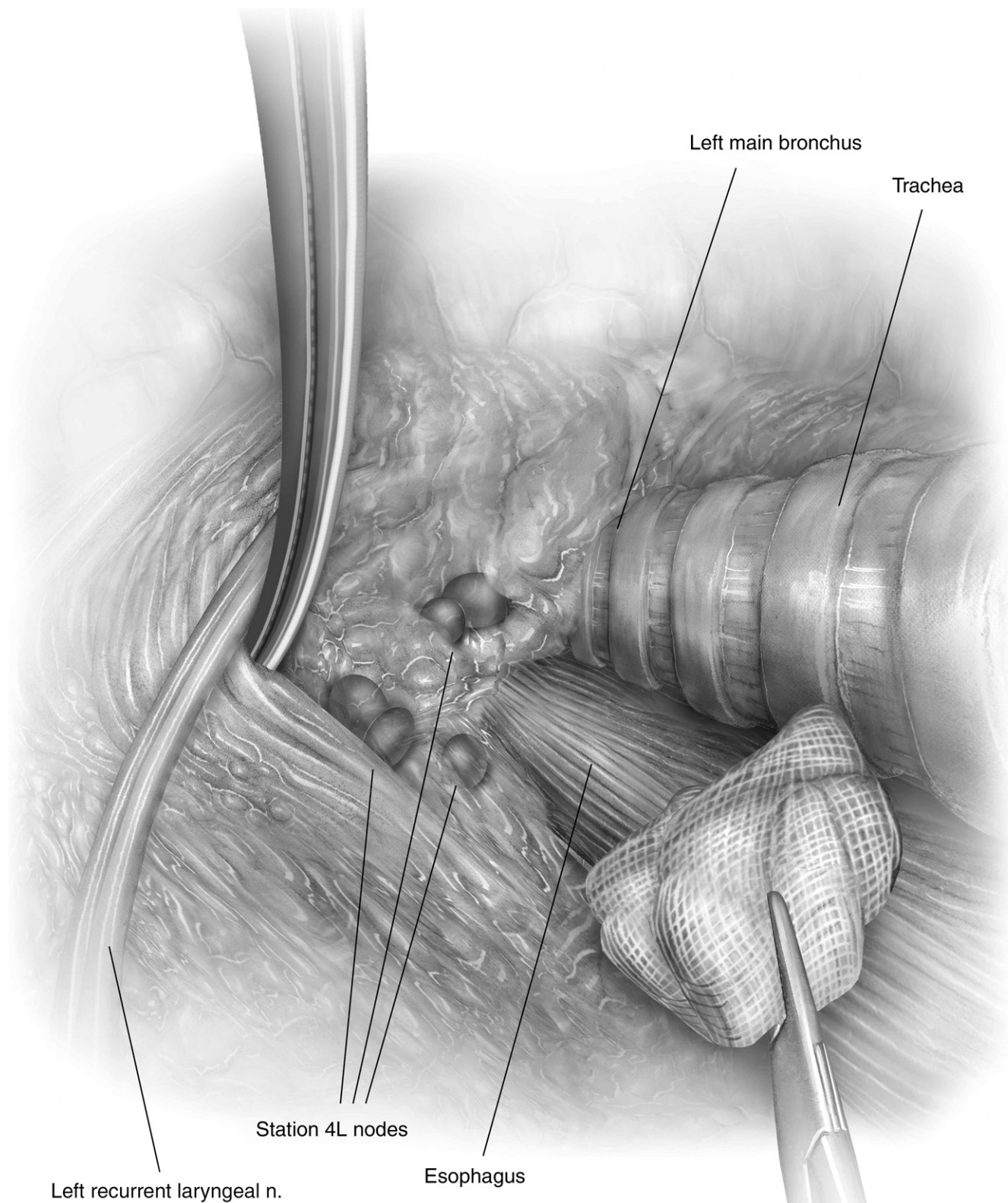


Figure 7 Dissection and removal of the left lower paratracheal nodes (station 4L). n. = nerve.

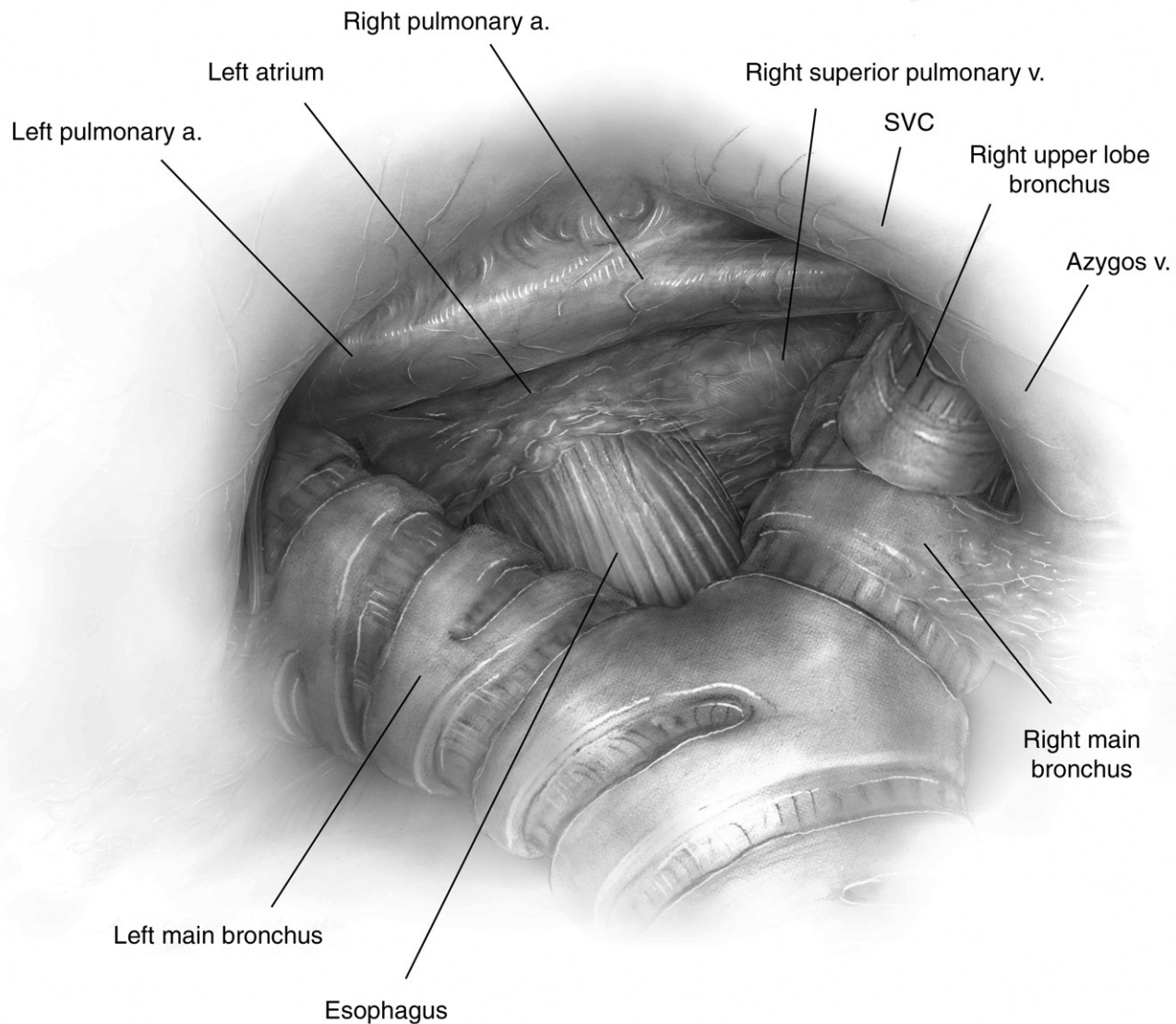


Figure 8 View of the subcarinal region after removal of the subcarinal (station 7) and the periesophageal (station 8 nodes). a. = artery; SVC = superior vena cava; v. = vein.

The Subcarinal and Periesophageal Nodes (Stations 7 and 8)

To enter the subcarinal nodes, it is necessary to divide the firm fascial layer covering the station 7 nodes anteriorly. Dissection proceeds along the medial walls of both main bronchi for 4 to 5 cm. The package containing the station 7 and 8 nodes is dissected from the pulmonary artery, the pericardium covering the left atrium (anteriorly), and the esophagus (posteriorly) and is then removed en-bloc (Fig. 8). For the removal of the subcarinal and periesophageal nodes (stations 7 and 8), a mediastinoscope is used; we prefer to use the operative Linder-Dahan videomediastinoscope (Richard Wolf GmbH, Knittlingen, Germany), which is equipped with moving blades that are very useful in retracting the pulmonary artery from the carina during dissection of node station 7, and the left atrium from the esophagus during dissection of node station 8, to 5 to 8 cm below the carina. The mediastinoscope is used for retracting these structures and for visualization only. Removal of lymph nodes is performed using a standard dissector for

open surgery, introduced through the right paratracheal space along the mediastinoscope.

The Aorta-Pulmonary Window and Para-Aortic Nodes (Stations 5 and 6)

The entrance to the aorta-pulmonary window and station 6 nodes lies between the left innominate vein and the left carotid artery. The first step in reaching this area is to divide the firm layer of the fascial tissue between the innominate artery, the left carotid artery, and the left innominate vein (Fig. 9). The fascial layer obscures the view of these vessels and, after its division, the left innominate vein can be retracted anteriorly. After retracting the vein upwards by using a long retractor, the plane is developed at the anterior surface of the aortic arch. With blunt dissection using a peanut sponge, the fatty tissue containing the station 6 nodes is dissected of the ascending aorta until the left pulmonary artery is reached. The left vagus nerve is a landmark of dissection. The nodes located above the convexity of the aortic arch and lying in front of the vagus nerve cross the aortic arch and the Botallo ligament and the para-aortic nodes (station 6). The nodes are

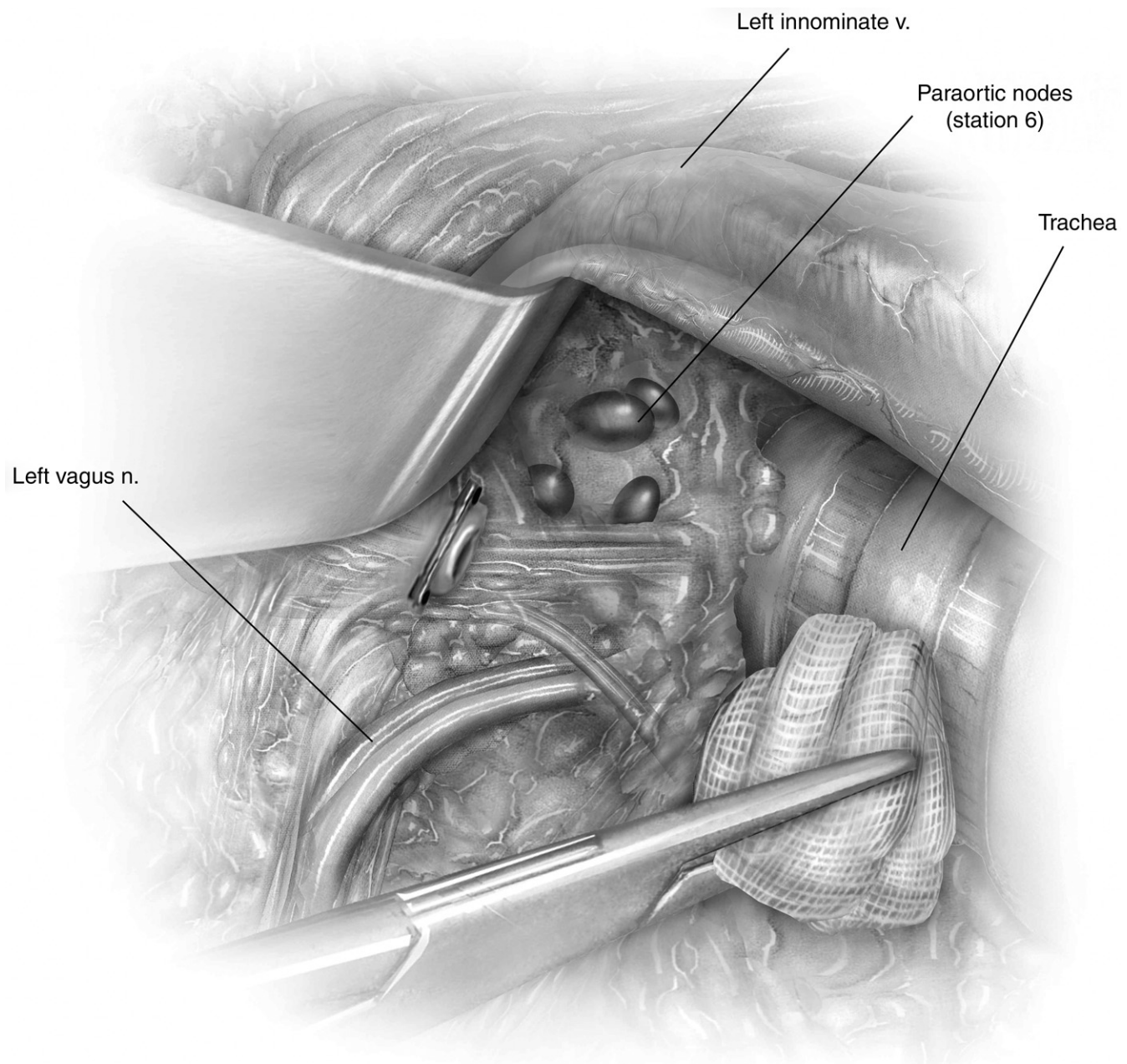


Figure 9 Entrance to the left para-aortic space containing the para-aortic (station 6) and the aorta-pulmonary window (station 5) nodes. n. = nerve; v. = vein.

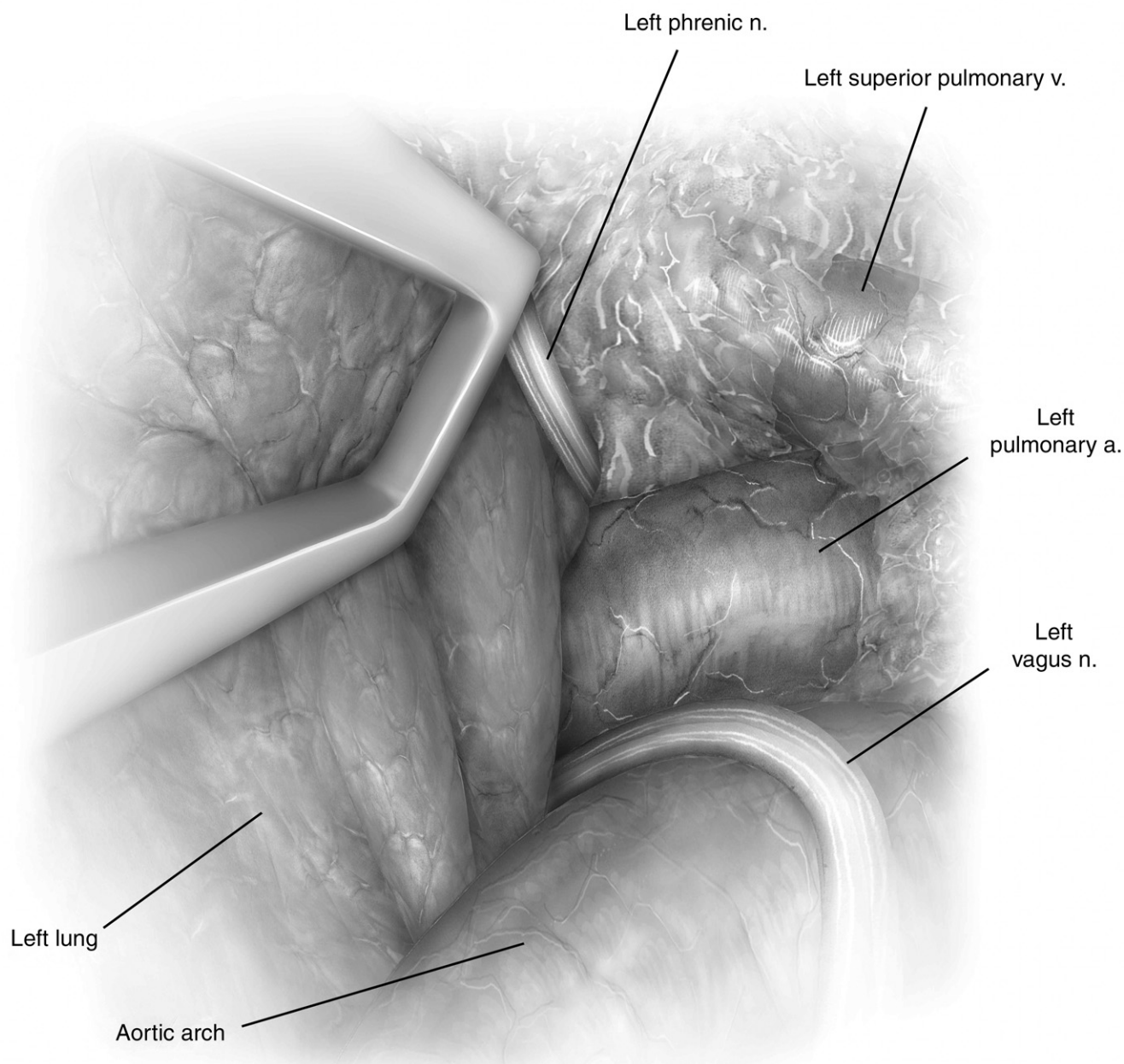


Figure 10 View of the aorta-pulmonary window area after dissection of the station 5 and station 6 nodes. a. = artery; n. = nerve; v. = vein.

located below the aortic arch and behind the Botallo ligament and the pulmonary-window nodes (station 5). Left pulmonary artery, the left phrenic nerve, and the left superior pulmonary vein are well visible after completion of dissection (Fig. 10). In case the mediastinal pleura opens, there is no need to drain the mediastinum. Inserting a piece of fibrin sponge and hyperinflating the lungs during closure of the wound is all that is necessary in such cases. The same rule is valid if the mediastinal pleura is opened on the right side.

The Prevascular and Retrotracheal Nodes (Stations 3A and 3P)

Stations 3A (prevascular nodes) and 3P (retrotracheal nodes) are removed in selected patients. Station 3A nodes lie below the left innominate vein, in front of the superior vena cava,

medially to the right mediastinal pleura, and laterally to the ascending aorta. These nodes are dissected after removal of station 1 nodes. The left innominate vein and the superior vena cava are retracted posteriorly with a peanut sponge and the fatty tissue containing the 3A nodes is dissected from the structures mentioned above (Fig. 11). In our experience, these nodes are rarely the site of metastasis in the case of the right-sided tumors.

The retrotracheal nodes (station 3P) are located behind the bifurcation of the trachea. This area is approached in same fashion as the right paratracheal nodes. The tracheal bifurcation is retracted anteriorly, which enables the visualization of the nodes lying in front of the esophagus. The nodes are easily removed; however, we never found any metastatic nodes in this station and most often there are no visible nodes in this location at all.

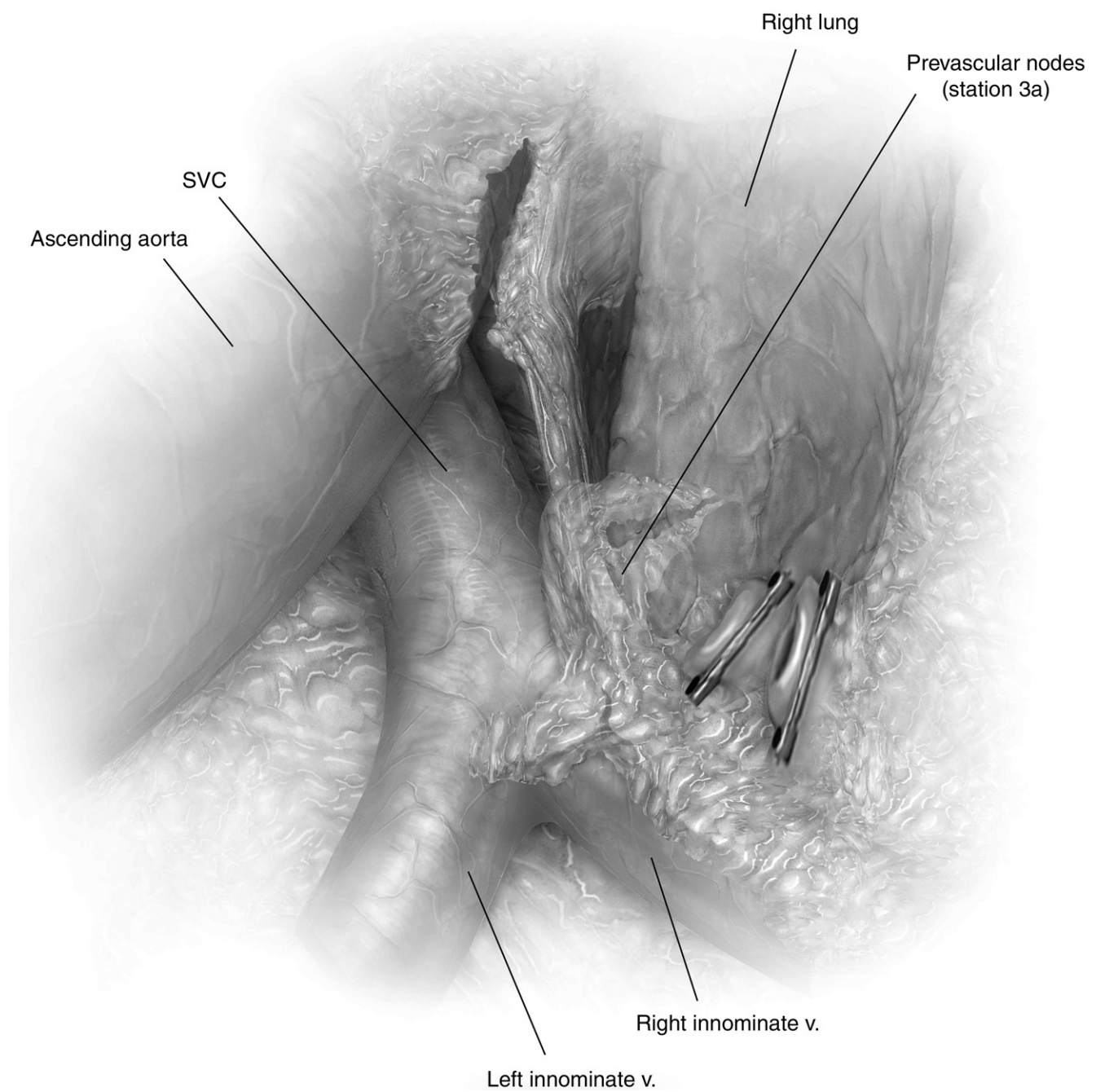


Figure 11 Dissection of the prevascular (station 3A). SVC = superior vena cava; v. = vein.

The Extensiveness of TEMPLA

During TEMPLA, all mediastinal lymph nodal stations and the surrounding fatty tissue are removed with the exception of the pulmonary ligament, station 9 nodes.

We try to follow the rule of performing lymphadenectomy in en-bloc fashion, at least in part, with resection of the whole package of the lymphatic tissue without separation of the individual nodes. It is possible to remove all the nodes of station 1 in one piece containing also the upper poles of the thymus. Afterward, stations 2R and 4R are removed in one piece; the same is done for stations 7 and 8 and 5 and 6. We remove the nodes of stations 2L and 4L separately because they almost never occur in one piece of tissue.

Generally, TEMPLA is an open procedure, with the exception of dissection of the subcarinal (station 7), the periesophageal (station 8) nodes, and the left lower paratracheal (station 4L) nodes, which are dissected in the mediastinoscopy-assisted fashion with the aid of Linder-Dahan two-blade mediastinoscope. The para-aortic, station 6 and aorta-pulmonary window, station 5 nodes are sometimes dissected with the aid of videothoracoscope introduced to the mediastinum through the operative wound.

Bilateral supraclavicular lymphadenectomy and even deep cervical lymph node dissection is possible during TEMPLA through the same incision, although we do not recommend this addition for routine use for NSCLC.

Conclusions

Currently, the indications for TEMPLA in NSCLC in our department include preoperative staging of potentially operable patients, regardless of the mediastinal nodal status on CT or positron emission tomography/CT. In all patients TEMPLA is preceded by previous combined EBUS/EUS examination. In case of a positive result of EBUS/EUS, patients are referred to neoadjuvant chemotherapy. The whole morbidity of TEMPLA was 6.8% with only one major intraoperative complication—injury of the right main bronchus successfully managed with fibrin sponge packing. The overall laryngeal recurrent nerve palsy is 2.7% but only 0.3% for the permanent palsy. The 30-day mortality of TEMPLA was 0.8%; in all cases; death was the result of comorbidities. Diagnostic yield of TEMPLA is as follows: sensitivity: 95.6%; specificity and

positive predictive value: 100%; negative predictive value: 98.4%; accuracy: 98.8%.

The extended transcervical approach with elevation of the sternal manubrium used for TEMPLA has been used successfully for several other indications.

The most important application of this approach to the chest includes transcervical-subxiphoid-VATS (videothoracoscopy) maximal thymectomy with a combination of transcervical and subxiphoid incisions with double elevation of the sternum.⁴ The thymus gland with the surrounding fatty tissue is removed en-bloc with the maximal extensiveness similar to the technique described by Jaretzki and Wolff.⁵ This technique was used for 291 thymectomies for myasthenia gravis, including 8 patients with thymomas. The transcervical approach was used in 60 patients for resection of mediastinal tumors located in the anterior, middle, and superior part of the posterior mediastinum and even in the lower mediastinum below the tracheal bifurcation.

The transcervical approach was used successfully for closure of the bronchial fistula after right pneumonectomy in one patient but was also tried unsuccessfully in two other patients because of anatomical difficulties, which show some limitations of the transcervical approach. The transcervical approach with single-port VATS for insertion of the camera was used successfully for right upper pulmonary lobectomy in two patients with NSCLC.

The use of TEMPLA is a very promising application in esophageal resection with three-field lymphadenectomy (combined with laparotomy, which was done in 14 patients, or with laparoscopy, which was done in three patients).

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